

Diversification of the hydromorphological state and the habitat quality of streams in the Negev Desert (Israel)

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Abstract The hydromorphological state and habitat quality of the selected streams in the Negev Desert was taken under consideration in the paper. Field studies were conducted in September 2014 on selected 500 m sections of streams (Nahal Be'er Sheva, Nahal Hebron) characterized by noticeable anthropopressure as well as on streams (Nahal Sansana, Nahal Yatir, Nahal Hatira) without visible human pressure. The survey of the hydromorphological state of selected streams was carried out using a British method, the River Habitat Survey (RHS). The hydromorphological state and habitat quality of the tested streams, based on the habitat naturalness indicator (HQA), as well as the habitat modification indicator (HMS), places the analysed streams of weak anthropopressure in class III—moderate (Nahal Yatir, Nahal Hatira) and IV—poor (Nahal Sansana). Bad hydromorphological state (class V) is the characteristic of the Nahal Hebron and Nahal Be'er Sheva streams with significant

human pressure. However, it is important to verify RHS method and the classification of a hydromorphological state, especially the HQA index, and adapt them to the reference conditions in arid and semi-arid areas.

Keywords Hydromorphological state · Habitat quality · RHS method · Human impact · Negev Desert, Israel

Introduction

The hydromorphological state of a river is dependent on the features of the natural environment of the drainage basin, and particularly on the lithology and geomorphology, climatic conditions, hydrological regime, the type and density of the vegetation cover, as well as the anthropopressure. Due to the above, rivers from different climatic zones are characterized by a diversified hydromorphological state. The extant literature devotes most of its attention to the hydromorphology of rivers in temperate and subtropical climate areas (e.g. Balestrini et al. 2004; Raven et al. 2005; Kamp et al. 2007; Urošev et al. 2009; Wiejaczka et al. 2014; Wiejaczka and Kijowska-Strugała 2015). There is a lack of studies focussed on the hydromorphological state of rivers in arid and semi-arid regions. Due to the specificity of the natural environment, these areas are characterized by a small degree of vegetation cover and limited infiltration, which promotes surface runoff (Laronne et al. 1992). Run-off generated on slopes is concentrated into the channels network to create flash floods. Within minutes, the flood rise from dry channel bed to its peak discharge and can last few hours or days. Flood waters infiltrated into the alluvial channels support thero-phyte, hemicryptophyte and phanerophyte vegetation between floods, a time span that can last days, months and

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even few years. Such extreme conditions that characterize the desert flow regime conduct a challenge to test the RHS in desert areas.

The determination of the hydromorphological state makes up an integral part of research on the abiotic and biotic diversity and serves for a better understanding of the functioning of the fluvial ecosystems (Elosegi et al. 2010). River regime of ephemeral streams is characterized by extreme diversity of flow dynamics over the year, which makes the subject matter of the hydromorphology of these areas a particularly problematic issue. The disrupting factor with regard to the natural morphology of the rivers is human activity. An example of human activities that directly change the river habitat is, inter alia, flow regulation, fragmentation of the riverbed with water structures, stabilization of the banks, and the exploitation of aggregates, among many others (Wohl 2006). Elosegi et al. (2010) state that human activity leads to the transformation of the natural environment into a more homogenous and less diversified one.

The habitat quality of rivers is a reflection of their hydromorphological state. Generally, the greater the number and diversity of natural features, the better the conditions for a river habitat is. However, the appearance of anthropogenic components indicates modifications to the river habitat (e.g. Raven et al. 1998; Environment Agency 2003; Szoszkiewicz et al. 2006).

An attractive area to carry out research on the hydromorphological state of rivers of arid and semi-arid regions is the Negev Desert in Israel. The research on the rivers of the Negev Desert conducted thus far, concerned, inter alia, the course, effects and predictions of floods (Greenbaum et al. 1998; Kahana et al. 2002, 2004; Bergman et al. 2014), sediment yield (Reid et al. 1995, 1998; Schick et al. 1997; Clapp et al. 2000), the human impact on the morphology of ephemeral streams (Hassan and Egozi, 2001), as well as the properties of rocks and soils as the most important factor affecting the spatial diversification of plant occurrence (Olsvig-Whittaker et al. 1983; Hoffmann et al. 2012).

The basic purpose of the undertaken research was to evaluate the hydromorphological state and quality of the habitat (the degree of naturalness and transformation by human activity) of selected streams of the Negev Desert based on the River Habitat Survey method (RHS). Field studies were conducted in September 2014 on selected 500 m lengths of streams distinguished by noticeable human interference (Nahal Be'er Sheva, Nahal Hebron) as well as on lengths without visible human pressure (Nahal Sansana, Nahal Yair, Nahal Hatira).

Study area

The Negev Desert is a triangle shape area of $\sim 10,000 \text{ km}^2$ with corners at the 3 base levels: the Mediterranean, the

Dead Sea and the Gulf of Eilat (Fig. 1). The temperatures range is between 40°C (sometimes even more) in summer and 8°C in winter (sometimes temperature drops below zero, and snow covers the high mountains of the central Negev). The mean annual rainfall drops from about 300 mm in the northern part to 27 mm in the southern corner. The rain to northern part of the Negev comes from the Mediterranean while most of the area is under the regime of the Red Sea Trough characterized by convective and spotty rainfall with high intensities. Outcome of the rainfall is flash floods.

The Negev Desert has undergone an urban and agricultural development during the last 70 years, and it continues intensively nowadays. Such intensive development causes a great interference in the drainage network of the streams, especially to protect human infrastructures from flash floods. Therefore, assessment of the hydromorphological state of rivers in areas with visible anthropopressure is important to monitor the quality of the environment and determine the direction of hydromorphological changes.

Large part of northern and central parts of the Negev is drained toward the Mediterranean by the large catchment of Nahal Besor, about $3,400 \text{ km}^2$. Four of the catchments in this research are tributaries of Nahal Besor: Nahal Sansana, Nahal Yatir, Nahal Hebron and Nahal Be'er Sheva. The fifth catchment is Nahal Hatira that flows through the Central Negev and is a tributary of the large Nahal Zin that drains to the Dead Sea (Fig. 1). The research was conducted on selected 500 m lengths of the 5 ephemeral streams mentioned above, which are characterized by a varied degree of human pressure (Figs. 1, 2; Table 1). The Nahal Sansana originates in the Hebron foothills, about 12 km north-east of Be'er Sheva, which is the main urban centre of the Negev Desert. Investigations were conducted in its lower course, ca. 1 km from the confluence with Nahal Rimon.

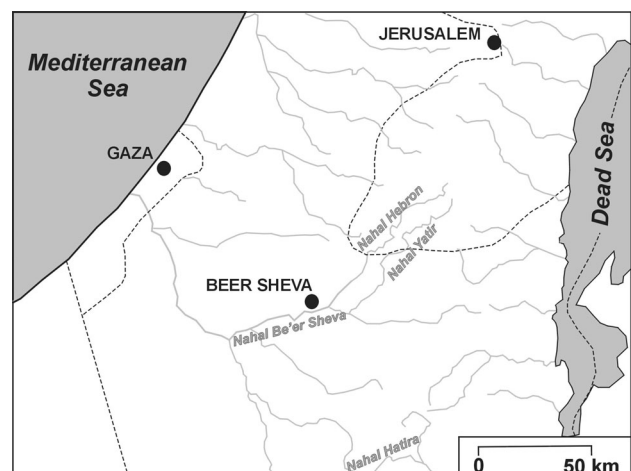


Fig. 1 Location of the stream in Negev Desert

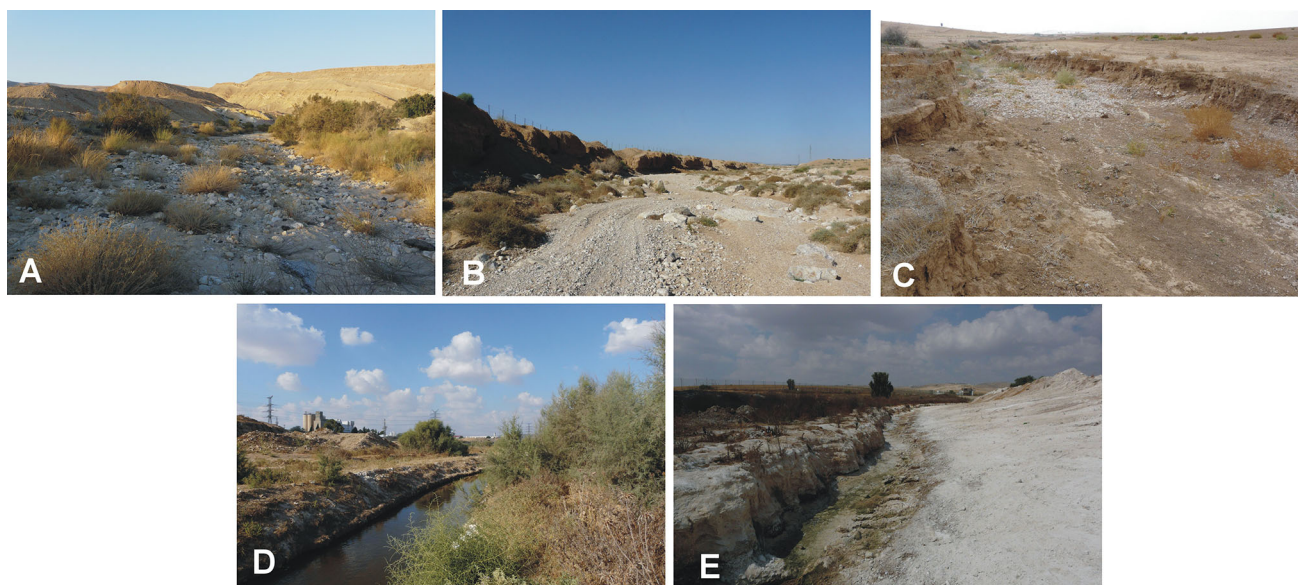


Fig. 2 Channel of selected stream in Negev Desert (a Nahal Hatira; b Nahal Yatir; c Nahal Sansana; d Nahal Be'er Sheva; e Nahal Hebron)

Table 1 Global Positioning System coordinates of the first RHS cross-profile in the select streams in Negev Desert

Streams	Localization	GPS coordinates of the first RHS cross-profile
The Nahal Sansana	The Northern Negev Desert	31°18'54"N, 34°54'11"E
The Nahal Yatir	The Northern Negev Desert	31°16'22"N, 34°56'33"E
The Nahal Hebron	The Northern Negev Desert	31°20'24"N, 34°55'54"E
The Nahal Be'er Sheva	The Northern Negev Desert	31°14'6"N, 34°48'15"E
The Nahal Hatira	The Central Negev Desert	34°57'5"N, 35°01'25"E

The Nahal Yatir drains a catchment of 19 km² which lies on the south-western flank of the Hebron Mountains, about 15 km north-east of Be'er Sheva. Elevations are 500–600 m.a.s.l. between the higher Hebron Mountains and the loess-clad Be'er Sheva Valley. The geological setting is three parallel monoclinical ranges plunging southwards into the Be'er Sheva Valley, between which Nahal Yatir and Nahal Anim have incised. Exposures of Senonian chert and chalk as well as the Neogene Yatir Breccia are found in the southern part of the Yatir Basin. Most of the basin is loess clad, the loess thickness increasing down valley. Loess thickness may attain 2 m in the valley bottoms, where it is intercalated with recent gravelly alluvium (Laronne 2000). Vegetation cover is sparse except for a planted forest in the north end of the basin.

The Nahal Hebron drains a 250 km² elongated basin in predominantly limestone bedrock within sub-humid parts of the Hebron Mountains (Hassan and Egozi, 2001). Investigations were conducted in the middle course of the stream, on a stretch markedly transformed by man, at the border with the Palestinian Authority (ca. 220 m from the border).

The RHS investigations were also carried out on the regulated section of Nahal Be'er Sheva, ca. 2.5 km below

the junction with Nahal Hebron in the town of Beer Sheva. The Northern Negev Desert region receives 230 mm of rainfall a year, mainly in winter between November and March, but potential evaporation is 2000 mm (Laronne et al. 1992).

The next analysed stream is Nahal Hatira (266 km²), which drains limestone, dolomite, chalk, conglomerate and sandstone and is located in the Central Negev Desert. It is the largest tributary of Nahal Zin. The mean annual rainfall of Nahal Zin catchment (1,400 km²) watershed varies from 90 mm in its upper parts to 50 mm and less in the lower reaches (Frumkin et al. 1998; Greenbaum et al. 2002). The RHS investigations were conducted in its middle course.

Methodology

A field study of the hydromorphological state of selected streams of the Negev Desert was carried out using a British method, the River Habitat Survey (RHS). The RHS method was developed in the early 1990s by the British Environment Agency. It is the most commonly applied method of evaluating the hydromorphological state of streams (Buffagni and Kemp 2002; Hawley et al. 2002; Buffagni et al.

2004; Erba et al. 2006; Szoszkiewicz et al. 2006; Raven et al. 2008; and others). Guidelines for conducting investigations using the RHS method are contained in the publications by Raven et al. (1998) and the Environment Agency (2003).

According to RHS method, rules 500 m length representative of the streams have been chosen for investigation. The investigation was carried out in two stages. In stage one, characterization is made of the basic morphological features of the riverbed and banks at 10 profiles located at 50 m intervals. Also, an evaluation was made of the structure of the aquatic and riparian vegetation, as well as the use of the river valley area. In second stage, the synthetic description of hydromorphological state for the entire section was made. It includes the various morphological forms and transformations that were not recorded in the previous stage.

The acquired material enabled to calculation of the synthetic indices: Habitat Quality Assessment (HQA) and Habitat Modification Score (HMS), being the resultant of many single basic parameters that make it possible to evaluate the hydromorphological properties of the river in numerical form. Thanks to the HQA indicator, it was possible to evaluate the variety of the natural elements of the riverbed and valley. Points were scored for the presence of features such as: side and midchannel bars, eroding cliffs, backwaters and floodplain wetlands. Additional points reflected the variety of channel substrata, flow types, in-channel vegetation, and also the distribution of bank-side trees and the extent of near natural land use adjacent to the river. Points were added together to provide the HQA score.

The Habitat Modification Score (HMS) was calculated based on the information on the kind and number of water structures, embankments, changes to the riverbed profile and the disturbances in water relations in the valley. These elements were assessed with scores, the sum of which determines categorization of the analysed section with regard to the hydromorphological state and the quality of the habitat. Greater and more severe modifications result in a higher score. Higher HMS scores reflect more artificial intervention and modification of the river channel within a site. A stream is distinguished by the best hydromorphological conditions if it has high HQA scores and low HMS scores (Raven et al. 1998; Environment Agency 2003).

In this research, the quantitative characteristic of the hydromorphological state of selected streams of the Negev Desert has been presented in the form of percentages of the particular cross sections (located at 50 m intervals) in which occurrence of the given natural and anthropogenic elements was found, in the total number of profiles (10) along the whole 500 m section under investigation. The characteristic of the channel bed was related to 10

transverse profiles, whereas in the case of the banks, the total number of observation points was 20 (10 for the left and right bank each in the particular transverse profile).

The terminology used in the RHS method is often a far-reaching simplification of the terms used in the different fields of environmental sciences (especially geomorphology). In order to avoid terminological ambiguities, in the analytical part of this paper, the meaning of the used terms that might cause doubts among readers is unequivocally explained. A detailed description of the terminology used in the RHS method is contained in the papers by Raven et al. (1998) and the Environment Agency (2003) that constitute as fundamental reading matter for all interested in this method.

Results and discussion

Hydromorphological state of streams without noticeable anthropopressure

In three selected streams in the Negev Desert: Nahal Sansana, Nahal Yatir and Nahal Hatira, there were no noticeable human activity. The material forming the banks of the channel of Nahal Sansana and Nahal Yatir in the examined sections is finely grained material, defined in the RHS method as soil, which was found in all of the examined transverse profiles (Table 2). In the case of Nahal Hatira, the basic material building the banks of the channel is sand (<2 mm), which constitutes 95% of the analysed measured profiles. Additionally, on the riverbanks, bedrocks were observed constituting 5% of the profiles. A natural element of the channel banks is an eroding cliff, which constitutes 60% of the profiles on Nahal Yatir and 10% each on Nahal Sansana and Nahal Hatira (Fig. 3, Table 2). No anthropogenic modifications of the banks or the channel bottom were found in the examined sections of the streams in the form of being artificially reinforced or resectioned.

The material on the channel bottoms of the analysed streams varied. Silt is predominant in Nahal Sansana channel (70% of profiles records) over gravel (30%), while in Nahal Yatir, gravel prevails (90%) in relation to bedrocks (10%). In Nahal Hatira channel, sand prevails (70%) over gravel (20%) and bedrocks (10%) (Table 2).

Natural morphological elements of the bottom were observed in two streams: Nahal Yatir and Nahal Hatira (Table 2). Bedrocks were predominant in the channel of Nahal Hatira (30%). Their presence was also found in Nahal Yatir (10%). Among the natural elements of the bottom, exposed boulders were also distinguished, and those were observed in 30% of the profiles on Nahal Yatir channel and 20% on Nahal Hatira, as well as unvegetated

Table 2 Hydromorphological state of the studied sections of the selected Negev Desert streams (%)

Elements	Streams				
	Nahal Sansana	Nahal Yatir	Nahal Hatira	Nahal Hebron	Nahal Be'er Sheva
<i>Bank material</i>					
Soil	100	100		80	100
Bedrocks			5		
Concrete				20	
Sand			95		
<i>Bank modification</i>					
None	100	100	100		
Reinforced				20	20
Resectioned				100	100
<i>Natural bank features</i>					
None	90	95	90	100	100
Eroding cliff	10	60	10		
Unvegetated side bar		5			
Vegetated side bar		5			
<i>Channel substrate</i>					
Bedrock		10	10		
Silt	70			70	100
Gravel	30	90	20		
Sand			70		
Concrete				10	
Invisible				20	
<i>Channel features</i>					
None	100	40	20	100	10
Bedrock		10	30		
Exposed boulders		30	20		10
Unvegetated midchannel bar		20	20		
Vegetated midchannel bar		20	10		90
Vegetated rock		10			
<i>Channel modification</i>					
None	100	100	100		
Resectioned				100	100
Reinforced				20	20
<i>Flow type</i>					
None	100	100	100	80	
Rippled					30
Upwelling					10
Smooth				20	60
<i>Land use within 5 m of banktop</i>					
Arable land	50	50			
Tall herbs	10	5			
Parkland or gardens					50
Natural open area without vegetation		45	95	70	20
Suburban/urban development	40		5	30	30
<i>Banktop vegetation structure</i>					
Uniform	65	15	35	15	40
Simple			20		
Bare	35	85	45	85	60

Table 2 continued

Elements	Streams				
	Nahal Sansana	Nahal Yatir	Nahal Hatira	Nahal Hebron	Nahal Be'er Sheva
<i>Bankface vegetation structure</i>					
Uniform	95	45	50	15	60
Simple			10		
Bare	5	55	40	85	40
<i>Channel vegetation types</i>					
None	50	70	40	100	
Emergent narrow-leaved water plant	50	30	60		100

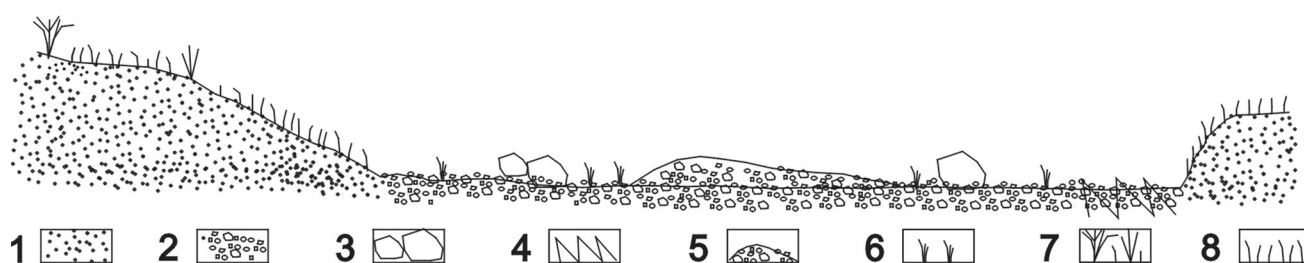


Fig. 3 Hydromorphological features of Nahal Hatira (on the example of fourth cross section). 1 finely grained material; 2 sand and gravel; 3 exposed boulders; 4 bedrocks; 5 unvegetated midchannel bar; 6

emergent narrow-leaved water plant; 7 simple vegetation structure; 8 uniform vegetation structure

side bars (20% each) and fixed by vegetated side bars (20 and 10%, respectively) (Table 2). Additionally, lichenized bedrocks and boulders were observed on the Nahal Yatir.

In the RHS method, based on the characteristics of the surface of the flowing water, velocity and direction of the current and the effect of the flow on the sediment of the channel bottom of the stream, nine types of flow were distinguished.

Concerning land use in a 5-m belt from the top of the banks (according to the RHS method, this is defined as land adjacent to the top of the bank, transforming into a flood terrace of the length of 1 m), along the analysed sections of Nahal Sansana and Yatir courses, there occur mainly arable lands (50% each), while at Nahal Hatira, natural open area without vegetation (95%). An essential element of land use of the valley bottom in the close vicinity of the stream channels is suburban development in the form of an asphalt road (Nahal Yatir, 45%) and a car park (Nahal Hatira 5%).

The distinction of the structure of the riparian vegetation in the RHS method is based on four categories (complex, simple, uniform or bare earth). The components correspond to the vegetation types that contribute to the shaping of the vertical structure of the bank. In the RHS method, the structure of vegetation is recorded separately for the bank top and bank face (the area between the bank top and the water level in the riverbed). On bank tops of the investigated sections of the streams, mainly uniform structure with one

developed type of vegetation is found (Nahal Sansana 65%, Nahal Yatir 15%, Nahal Hatira 35%) as well as the absence of vegetation (35, 85 and 45%, respectively). The simple structure, defined as two or three types of plant vegetation, including bushes and trees, was observed only on the bank tops of Nahal Hatira (20%) (Table 2). On bank faces of Nahal Sansana and Nahal Hatira, a homogenous vegetation structure was predominant (95 and 50%, respectively), while on the bank face of Nahal Yatir, no vegetation was observed for the most part (55%).

An essential element that directly affects the hydromorphological state of a stream is also aquatic vegetation, the diversity of which provides good habitat conditions for invertebrates and other organisms. At all of the sections of the streams, the presence of emergent narrow-leaved plants was observed and these were recorded at 30 to 60% of the profiles (Table 2).

Hydromorphological state of streams with significant anthropopressure

The fundamental manifestation of the human pressure on the selected sections of the streams Nahal Hebron and Nahal Be'er Sheva is modifications of the morphology of considerable sections of the banks. Reinforced (bank artificially strengthened for bank protection purposes) and reprofiling (bank profile modification) banks were observed

on both of the streams with similar scale of human interference (Table 2). On both streams, reprofiling of the banks was recorded at all profiles, and reinforced banks in the form of concrete were found at 20% of the profiles.

The predominant bank material at both streams is finely grained material, which occurred at 80% of the profiles in Nahal Hebron and 100% in Nahal Be'er Sheva. Additionally, at 20% of the profiles in Nahal Hebron, concrete was observed (the right channel bank). No natural morphological bank elements were recorded on the investigated sections of the streams.

The predominant material forming the riverbed bottom is silt, which occurred at 70% of the profiles in Nahal Hebron and 100% in Nahal Be'er Sheva. In Nahal Hebron, 10% of the profiles featured concrete. No natural morphological bottom elements were recorded in this stream, whereas in Nahal Be'er Sheva, vegetated channel bars were recorded at 90% of the profiles and exposed boulders at 10% (Table 2).

In Nahal Hebron, at 80% of the profiles, flow was not recorded due to the drying up of the channel. Smooth flow (slow laminar flow, not stirring up the surface of the water) was recorded at 20% of the profiles. In Nahal Be'er Sheva, smooth flow was recorded at 60% of the profiles, rippled flow (the surface of the water forms characteristic 1 cm high ripples that move along the stream) at 30%, and upwelling (rapid flow with short waves with glassy crests) at 10% of the profiles (Table 2). Flows in analysed streams are artificial, and it is mainly sewage. The flash floods are the dominant flow.

With regard to land use within 5 m of the bank tops of Nahal Hebron, there are predominant natural, open areas without vegetation (70% of the profiles) as well as suburban development (30%) in the form of roads. On stretches of Nahal Be'er Sheva, these elements score 20% and 30%, respectively. The prevailing element in the structure of the land use of the valley bottom in the immediate proximity of Nahal Be'er Sheva riverbed is parks and gardens, which occur at 50% of the profiles. The structure of vegetation both at the top and on the face of the banks of the compared

streams demonstrates similarity. Only transverse profiles were recorded with a homogenous structure and were unvegetated due to the embankments and the reprofiling of the banks (Table 2).

Despite considerable manifestations of human pressure in Nahal Be'er Sheva riverbed, occurrence of an emergent narrow-leaved water plant was recorded at all profiles in contrast to Nahal Hebron (Table 2), in which aquatic vegetation did not occur.

Habitat quality of the streams based on the HQA and HMS indices

The values of the HQA index that indicate the degree of diversity of the natural hydromorphological elements of the habitat calculated for the particular research sections of the streams without noticeable human interference (Nahal Sansana, Nahal Yatir, Nahal Hatira) are comprised in the range of 10–32 (Table 3).

According to the Walker et al. (2002) classification (Table 4), developed for British streams, the sections of the streams analysed with regard to the diversity of the natural elements fall within the low (Nahal Hatira) and very low habitat quality (Nahal Sansana, Nahal Yatir) (Table 3). The value of the HQA index for the investigated sections was decisively affected by the small diversity of the material and natural morphological elements of the banks and riverbed (mainly on Nahal Sansana and Nahal Yatir), as well as land use in the valley bottom in the immediate proximity

Table 4 Categories of rivers according to the modification (HMS) and habitat naturalness index (HQA). *Source:* Walker et al. (2002)

HMS value	Type of habitat	HQA value	Quality of habitat
0–2	Almost natural	109–135	Very high
3–8	Slightly changed	82–108	High
9–20	Little changed	55–81	Sufficient
21–44	Much changed	28–54	Low
≥45	Highly changed	0–27	Very low

Table 3 HQA and HMS index values for the examined sections located on the selected streams of the Negev Desert. *Source:* Walker et al. (2002)

Index		Nahal Sansana	Nahal Yatir	Nahal Hatira	Nahal Hebron	Nahal Be'er Sheva
HQA	Average	10	26	32	6	15
Naturalness class		V	V	IV	V	V
		Very low	Very low	Low	Very low	Very low
HMS	Average	8	0	0	58	41
Transformation class		II	I	I	V	IV
		Slightly changed	Almost natural	Almost natural	Much changed	Highly changed
Hydromorphological state class		IV	III	III	V	V

Table 5 Classification of the hydromorphological state of streams based on the HQA and HMS index (I—very good, II—good, III—moderate, IV—poor, V—bad) (Walker et al. 2002)

	Intervals points HMS (classes)	Intervals points HQA (classes)				
		109–135 (I)	82–108 (II)	55–81 (III)	28–54 (IV)	0–27 (V)
0–2 (I)		I	II	II	III (Nahal Hatira)	III (Nahal Yatir)
3–8 (II)		II	II	III	III	IV (Nahal Sansana)
9–20 (III)		III	III	III	IV	IV
21–44 (IV)		III	IV	IV	IV	V (Nahal Be'er Sheva)
>45 (V)		IV	IV	IV	V	V (Nahal Hebron)

of the channels. Also, the structure of the riparian vegetation plays a major role in determining the habitat quality of the streams.

On the sections of Nahal Hebron and Nahal Be'er Sheva with noticeable human interference, the values of the HQA index amounted to 6 and 15, respectively (Table 3). According to the Walker et al. (2002) classification, they fall within the very low habitat quality, like the sections without visible human pressure. The slightly higher values of the HQA index for the Nahal Be'er Sheva result mainly from the greater diversity of the natural morphological elements of the bottom.

The Walker et al. (2002) classification is suited to rivers with different environmental features than the streams of the Negev Desert, and so it does not reflect the character of arid and semi-arid regions. It is of essential importance therefore to verify the ranges of the above classification of the HQA index and adapt them to the reference conditions of the rivers of the desert and semi-desert regions. Defining the score ranges requires gathering a rich database of scores from field measurements.

The values of the HMS index that define the degree of the anthropogenic changes in the hydromorphology of rivers calculated for the profiles without noticeable human interference with the hydromorphology amounted to 0 (Nahal Yatir, Naha Hatira) and 8 (Nahal Sansana), which indicates an almost natural and slightly changed habitat of the river (Walker et al. 2002). The increased value of the HMS index in Nahal Sansana was affected by, inter alia, the four fords with slight effects on the environment that were observed. At the same time, the sections of Nahal Hebron and Nahal Be'er Sheva, where modification of the morphology of the banks and the channel bottom was found in the form of embankment and reprofiling, are characterized by the greatest changes in the habitat as a result of human interference with the environment. The river habitat in the investigated sections of the Nahal Be'er

Sheva may be seen as considerably changed and that of the Nahal Hebron as very changed. The HMS index values amounted to 41 and 58, respectively (Table 3). The increased value of the HMS index in the Nahal Hebron was affected by, inter alia, two water culverts and a transverse structure with strong effect on the environment, as well as the absence of aquatic vegetation.

The hydromorphological state of the tested sections, based on the habitat natural indicator HQA, as well as the habitat modification indicator HMS, places the analysed streams of weak human pressure in class 3 (Nahal Yatir, Nahal Hatira) and 4 (Nahal Sansana) (Table 5). According to the Walker et al. (2002) classification, this indicates moderate and poor hydromorphological state of the mentioned streams. Bad hydromorphological state (class 5) is the characteristic of the Nahal Hebron and Nahal Be'er Sheva with marked human pressure.

Conclusions

The survey of the hydromorphological state and assessment of the habitat quality of selected streams of the Negev Desert carried out using the RHS method has demonstrated that:

1. The examined streams of small and significant human pressure are characterized by varied hydromorphological states and quality of the habitat;
2. The streams with slight human pressure demonstrated greater diversity of the natural elements in relation to the streams of strong human pressure. The high degree of diversity of the natural elements of the streams under consideration was attributed to the occurrence of the natural morphological elements of the banks (erosive cliffs, vegetated and unvegetated side bar), of the riverbed bottom (bedrocks, exposed boulders,

unvegetated and vegetated midchannel bar), as well as the channel vegetation.

3. The degree of modification of the hydromorphological state of the streams with slight human interference was primarily due to the presence of fords of weak effect on the environment, and in streams with strong human pressure due to the reinforced and resectioned banks and the bottom of the riverbeds, as well as the presence of a damming structure strongly affecting the environment.
4. Streams with weak human pressure are characterized by moderate and poor hydromorphological states, while streams with strong human pressure by bad hydromorphological states.
5. The classification of the hydromorphological states of streams, commonly applied in Europe, requires readjustment of the ranges for the particular classes of the HQA index to the desert and semi-desert conditions. The presence or absence of some hydromorphological elements in regions of different environmental features may be natural and does not indicate a bad hydromorphological state. For example, the riparian vegetation is almost missing in desert streams, so the change in weighting of this feature in the HQA index calculation is needed. After adjusting the class ranges of the HQA index to the conditions of desert and semi-desert rivers, the placement of the analysed streams in the individual classes might change.

The analysis presented in this paper therefore points to the necessity of adjusting the RHS method to the conditions of desert and semi-desert rivers. Defining the score ranges requires gathering a rich database of scores from field measurements.

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